

CERES + 15V Anomaly Report

Status reported as of September 2, 1998

**Compiled by
Greg Stover**

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Scope

This report describes the understanding of the effects and several of the possible cause mechanisms for the anomaly that has resulted in an increased voltage output on a voltage converter in the CERES Proto-Flight Model (PFM) instrument aboard the Tropical Rainfall Measuring Mission (TRMM). The report also discusses the activities conducted to understand the anomaly mechanism and the impact on the TRMM and other spacecraft. The information contained in this report is current as of the date on the cover page. The report also discusses the activities conducted to understand the anomaly mechanism and the impact on the TRMM and other follow-on spacecraft on which CERES will operate.

Anomaly Summary

The CERES Proto-Flight Model (PFM) instrument aboard the Tropical Rainfall Measuring Mission (TRMM) exceeded a yellow high limit for the Data Acquisition Assembly (DAA) +15 volt measurement on August 18, 1998. Upon review of instrument data it was noted the +15 volt level began increasing on July 31, 1998. The trend for the maximum voltage seen during a 24 hour period has been gradually upward since July 31st with an amplitude peak reaching approximately 16.9 volts on September 1, 1998. Due to overvoltage concerns for electronic parts downstream of the converter, the CERES instrument's operational power has been removed.

LaRC, TRW, and the TRMM Flight Operations Team continue to examine the CERES instrument and spacecraft data for an explanation and resolution to the anomaly.

Current Status

The Data Acquisition Assembly (DAA) +15 volt converter aboard the Clouds and the Earth's Radiant Energy System (CERES) Proto-Flight Model (PFM) exhibited increased cyclic voltage output with orbital temperature variations. It has been theorized that the gain of the converter's internal feedback loop has been adversely changed and is more sensitive to temperature variations thus causing the device to malfunction. The cause of the gain change has been conjectured to be high energy proton effects on an opto-coupler used in the converter's feedback element that controls the converter's output. High energy particle testing on a equivalent converter at the Jet Propulsion Laboratory (JPL) has verified similar behavior to that observed on the CERES PFM converter. Attempts to reduce the temperature of the device by changing the scan operation of the instrument and by rotating away from the solar thermal input have had negligible success at bringing the voltage to a more nominal level. (The voltage has reached a maximum of 16.9 volts during episodes of increase.) Concern exists for electronic parts downstream of the converter (operational amplifiers, multiplexers, and especially the analog-to-digital converter) which are susceptible to breakdown at voltage levels in excess of 17 volts. Because all attempts at reducing the voltage below a 16.5 volt peak have been unsuccessful, the instrument has been placed in a survival mode (instrument power off). Data from prior diagnostic tests and operational modes collected over the last few weeks is being reviewed to determine which additional diagnostic tests would provide insight into finding a cause of the problem and, hopefully, a correction.

In addition to the effect of space radiation, other causes for the anomaly are being examined for the voltage converter and associated circuits (premature component death, mechanical/electrical failure of solder joints).

Activities to discover anomaly mechanism

Several areas are the focus of efforts to understand the anomaly. A brief description of the efforts are described.

Data Examination

A large data set has been assimilated and is being analyzed in order to better characterize the observed effects which should lead to an understanding of the cause of the anomaly. This data includes CERES instrument engineering data, TRMM spacecraft data, as well as thermal, and space radiation models.

Voltage Converter

This effort involves obtaining a more detailed understanding of the internal components and failure mechanisms of the voltage converter. The design is proprietary but the manufacturer has cooperated with TRW in establishing the converter design and internal components, and is forming an internal group that will assist in the investigation.

On-Orbit Temperature Variation

It has been observed the converter voltage measurement varies synchronously with temperatures measured in the area of the converter. Orbital cycles, as well as a daily enveloping cycle have been observed. Analysis has shown that the voltage increases with increased temperature for both cyclic variations. The orbital cycles are understood, however, the daily enveloping cycle is not yet been explained. The TRMM Flight Operations Team and CERES personnel continue to examine orbital, spacecraft, and instrument data in order to determine the cause of the daily enveloping temperature variation that correlates to the increased voltage.

Space Radiation Effects

Langley Research Center Electronic, Electrical, Electro-Mechanical (EEE) parts personnel have been in contact with the Goddard Space Flight Center's radiation group to discuss further issues related to the operation of the converter in the flight environment. GSFC personnel are analyzing the radiation environment and are providing fluence data that can be used by the voltage converter manufacturer in order to determine the possible effects on the converter operation.

Additional Cause Mechanisms

Failure of other components in the instrument that are related to the voltage measurement, could also exhibit the same type of effect either by their failure or degradation. The converter is also being examined to determine if another cause besides radiation damage could also exhibit this increased voltage behavior.

Additional Instrument Impact Assessment

The potential impact of this anomaly on the other CERES instruments is being considered during the investigation of the cause mechanism. It is premature to conclude any possible impacts until the cause has been better definitized.

Impact to Spacecraft

TRMM

TRW is examining the mechanism of failure in the voltage converter to better understand the degradation that could occur if the device fails. Initial indications are that due to constant loading on the output side, the converter would obtain a maximum output voltage that is less than the input voltage. This in effect limits the power consumed by the device at this point and it would not be expected that a large or rapid current

increase would occur due to the degradation. The CERES instrument is not fused internally but over-current mechanisms are provided on the spacecraft bus in the form of a fuse. CERES has requested the Spacecraft implement an onboard autonomous telemetry monitor that would take certain actions in the event the monitored parameter exceeded a preset limit. In this case the parameter monitored is the output of the voltage converter and the resulting action would be to turn operational power off in the event the voltage reached a value of 16.3 volts. This voltage level has been observed in the past and it is known not to create a large current draw.

EOS AM-1, EOS PM-1, EOS Follow on

The five instruments for these missions utilize +15 volt converters from the same manufacturer. It has been established that the lot from which the anomalous operating TRMM converter was obtained, is different than the manufacturing lot that was used for the other instruments. At this time insufficient data is available to determine if the components used in these instruments could experience the effects from the currently speculated causes of the observed anomaly.

Summary

Efforts continue in the examination of instrument's performance data in order to better understand the effects and to draw conclusions for the anomaly's cause mechanism. TRW is holding discussions with the manufacturer of the voltage converter, and other instrument component manufacturers, for which the converter supplies voltage, in order to understand the operational limits and failure mechanisms of the devices. LaRC and GSFC EEE parts personnel and radiation experts are compiling data on the CERES components and the spacecraft environment in order to support further analysis and discovery. TRMM Flight Operations Team members continue to monitor the CERES temperatures in the survival mode, are supplying data on the TRMM spacecraft parameters, and are examining other spacecraft subsystem and instrument data in order to determine if a correlation exists with the temperature variations seen on the CERES instrument.

Data examination is intense at this time in order to understand the cause mechanism. As of the date of this report, it would be premature to conclude any single item mentioned above as the cause for the anomaly. The CERES project has decided to continue with the non-operational status of CERES until such time that the data provide a clearer indicator of the effects of the anomaly, and the additional protection afforded by the on-board telemetry monitor is in place prior to operating the CERES instrument. .